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Radar '77

CDR David A. Hart, USN

2 December 1977

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The Institution of Electrical Engineers and the IEEE Aerospace and Electronic Systems Society organized a major four day international conference, Radar-77, held in London 25-28 October 1977. A brief description of some of the papers presented at this conference is presented. A complete list of the papers at Radar 77 is included as an appendix.

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RADAR 77

I. Introduction

From 25 to 28 October 1977 a very large international conference on radar was held in London. Titled Radar-77, the conference was one of a tri-annual series held jointly by the Institution of Electrical Engineers (UK) and the IEEE Aerospace and Electronics Systems Society (USA) and, on this occasion, with the support of several other scientific associations in the UK. The location for the conference was the IEE headquarters in Savoy Place, London.

Some statistics about the conference will give an impression of its importance as a major forum for information exchange on radar technology. There were 625 radar specialists attending from 25 different countries. One hundred twenty papers were presented, most of the conference taking place in two simultaneous sessions. Nearly 100 people who wished to attend were turned away. Because of space limitations at the IEE, only about 600 people could be accommodated in the main conference room. By far the majority of attendees were from the UK as might be expected for a conference held in London, but there was a sizable representation from the USA and from other European countries. Those from New Zealand and Japan had probably traveled the farthest to be present, and there were even some from the Warsaw Pact nations (specifically, Poland), however it did not appear there were any from the USSR.

Of the papers presented at Radar-77 the majority (63) were by authors from the UK with the USA second (28). The remainder were mainly European contributions, but there were a few by engineers from as far away as Australia and Japan.

The keynote address at Radar-77 was delivered by Sir Hermann Bondi, who at that time was Chief Scientific Advisor to the UK Ministry of Defence, but later became Chief Scientist of the UK Department of Energy. Although not currently active in this field, he was a principal figure in radar's early days of development during WW II.

Sir Hermann's main point was that everything that was obvious and easy in radar seemed to have been thought of several years ago, and now radar engineers are tackling the things that are difficult and expensive. In current radar development one of the most difficult tasks is to be able to judge what people are capable of developing. There is a tendency to think that with the advent of computers

anything can be done, but results still depend on people and their capability to solve complex problems where not all the pitfalls are obvious at the outset. Sir Hermann outlined several areas where there still exists a need for fundamental information. Among these are: the effect of raindrop size distribution on the propagation of millimeter waves, the characteristics of sea clutter, and the man-machine interface in the radar system. The last area is one in which Sir Hermann thinks there is still much to be gained in radar system development.

It would be presumptuous of this writer to attempt a full survey and analysis of the content of Radar-77. In the first place it would require a radar expert (which I am not), and in the second, he would have to have been able to be in two places at once because of simultaneous sessions. To simplify the task while still hoping to produce a report that might be useful to my US colleagues, I have adopted a few ground rules. The papers that I have covered and abstracted are those I actually heard (approximately 1/2 of those presented); excluded from these are however, those by US authors and a few others which seemed to me to be less interesting or too specialized.

II. Papers of General Interest

Several sessions of Radar-77 were held without competition from simultaneous additional sessions. These were devoted to radar systems, multiple radar systems, and special applications, all topics with fairly wide appeal to the audience.

J. W. Sutherland (Marconi Radar Systems, UK) spoke on world market trends in radar and cited several techniques he believes would find more use in future radar systems. These were:

- antennas with low off-beam sensitivity to jamming (e.g., linear arrays)
- distributed data processing to reduce the complexity of central processors in radar systems, simplify interconnections, and to ease maintainence
- signal processing to reduce clutter
- more graceful degradation in radar systems, i.e., more fall-back performance and an established minimum performance capability for the entire radar system.

Professor J. J. Kroszczynski (Przemyslowy Instytut Telekomunckacji, Poland) described some Polish radars made both for domestic

application and export. These include the AVIA family of air traffic control radars (operating at L-Band, 23 cm); SRN-300 radars for small ships (operating in X-Band), and a CW X-Band Doppler radar for measuring vehicle speeds. This last system uses a Gunn diode transmitter. I don't think the Poles were giving anything away in the areas of new technology in this presentation.

J. G. Cochran (Plessey Radar Ltd, UK) made a pitch for a technique for air defense radars that has apparently had wide support in the UK but not elsewhere. This is the within-pulse scanning technique which uses an array producing a beam-elevation angle that is a function of the existing carrier frequency, and the full elevation angle is scanned within each pulse. This technique, first described in 1964, is claimed to have advantages of high data rate, less susceptibility to clutter and interference, and simpler operation than phase scanning and beam steering radars. The within-pulse scanning technique is combined with surface acoustic wave (SAW) devices for pulse compression to produce a system capable of meeting the most stringent requirements while still retaining reasonable peak-power levels.

A system that provided the basis for several papers was the FUCAS experimental phased-array radar system being developed in the Netherlands by the Physics Laboratory TNO. G. A. van der Spek described this system which transmits a pencil beam from a lens-type circular planar array. The lens contains 857 ferrite phase shifters and the resultant beamwidth is 4°. Van der Spek's presentation highlighted the problem of how to present information from a 3D radar and showed one interesting format for such a display, albeit an engineer's display, not an operator's display. This places the radar at the center with arcs above and below for constant altitude lines. Azimuth planes are outlined by diagonal lines passing through the center of the display. The FUCAS system is still being developed and is expected to be completed in early 1978.

M. Scorer (Marconi Elliot Avionic Systems Ltd., UK) described an advanced man-portable radar for battlefield surveillance. The Royal Signals and Radar Establishment (RSRE Malvern) has for several years had a program to develop successive generation of battlefield radars. It is believed there is nothing really new in the concept or technology, but the good engineering and low power consumption could make it an attractive product.

One of the most interesting papers to me personally was that presented by Prof. E.D.R. Shearman (University of Birmingham, UK) although I have subsequently been told it did not represent anything

new in technology. His paper concerned the use of HF over-the-horizon radar to measure wind conditions over the sea at great range ($\sim$ 3,500 km). The technique relies on Doppler analysis of the received signal. From the Doppler sea-backscatter spectrum and a semi-empirical relationship between wind and sea waves, it is possible to compute wind vector magnitudes. Good agreement has been obtained when results from the method were compared to actual wind direction. Shearman uses a 300-m-long array of 49 broadband monopoles in his experiments. For the recent experiments his carrier frequency was 10.363 MHz.

The UK seems to have developed a strong interest in multistatic radar to avoid interference in the main beam of a monostatic system. Five papers of the six presented in the Multiple Radar Systems Session were from the UK. These dealt mainly with system analyses of various multiple transmitter or multiple receiver systems. However, one paper that sneaked into their session was on system applications of beam forming networks (BFN's). M. J. Radford (Marconi Radar Laboratories, UK) discussed a family of IF BFN's using resistive elements. It is claimed that it is easy to design a resistive BFN to give beams of different widths or shapes and that systems based on resistive BFN's can be used to solve a whole range of radar problems (e.g., interference reduction, clutter isolation, and tracking).

A number of papers on special applications were given toward the end of Radar-77. These ranged from laser radars to geophysical prospecting, and, because of the unusual nature of the work discussed, were of considerable interest even though military applications were not a dominant theme.

K. E. Potter (RSRE, UK) presented an experimental design study of an airborne interferometer for terrain avoidance. Two vertically displaced antennas were fixed so as to receive the reflected return from a CW transmitter 200 m away. The interferometer was able to receive a valid angle return from terrain 78% of the time.

D. C. Oliver (RSRE, UK) presented a somewhat theoretical discussion comparing radar principles at microwave and optical frequencies. One salient point made in this paper was that the signal-to-noise ratio differs between microwave and optical detectors. For RF detection the noise-in-signal is proportional to the incident electric field amplitude while in photo detection it is proportional to the total incident power. This observation suggests that if photodectectors could be applied in the radar frequencies, noise-in-signal would increase less rapidly with increased incident power.

Dr. J. M. Vaughan (R.S.R.E, UK) presented a paper on a 10 μ-Band laser radar anemometer developed by RSRE and Marconi Elliot

Avionics Systems, Ltd. These workers have developed a scanning instrument that can measure wind velocities in each of sixty four 2.5 m cubes within a 10- m cube at a range of 100 m. This instrument is expected to be of value in studying turbulence in the vicinity of airfields.

W. A. Grinsted (Plessey Radar, UK) described the mapping of rainfall by radar and discussed the comparative accuracy of measurement of area rainfall by both radar and a network of rain gauges. The manner of presenting rainfall data was also described and typical results shown. Rainfall data are digitized and intensity is coded into one of 6 ranges to give a color presentation which can be displayed on an ordinary color TV. The data can also be transmitted at 600 bits/sec over telephone lines.

G. Neininger (Standard Elektrik Lorenz, West Germany) described a 16.5-GHz FM/CW radar for application to an anti-collision radar system for automobiles. One of the principal problems with such a system is the false-alarm rate caused by posts, trees, guard-rails, etc. The false-alarm problems have been largely solved through use of a microprocessor and associated software. SEL is now experimenting with a 35-GHz system that has the advantage of a smaller antenna.

A solid-state microwave-noise radar was described by T. R. Forrest (University College, London, UK). This system employs a 20mW X-Band Impatt diode producing 200-MHz bandwidth noise. Detection of targets is accomplished by delaying a sample of the transmitted signal and correlating it with the reflected signal. Delay and correlation are carried out at IF. Ranges achieved are only on the order of 25 m which would seem to limit the usefulness of a solid state noise radar to security devices and such.

D. J. Daniels (Plessey Radar Research Center, UK) and P.J.B. Clarricoats London University, UK) in separate papers described the use of radar to detect buried objects. Daniels has used radar to measure the thickness of coal seams in coal mines. It is possible to measure up to 0.15-m thickness with a radar operating around 1 GHz. Clarricoats has been experimenting with a sand-filled box to locate plastic pipes and similar objects buried in the sand with a 2-4-GHz FM CW radar.

D. S. Harris (Marconi Elliot Avionic System Ltd, UK) reported on measurements using a 35-GHz pulsed radar to detect electricity pylons and cables. This work has obvious application to low-level helicopter flying. One of the findings of this research is that broadside flash from an electricity cable provides signal return comparable in amplitude to that from a pylon. There are also secondary returns due to the cables' wrapped construction and these occur at

angles dependent on the distance between strands.

III. Papers on Data Extraction, Plot Tracking and Analysis

In this section I will describe some of the papers given in two different sessions of Radar-77: data extraction and computing, and plot tracking and analysis.

R. J. Tuncliffe and J. E. Holmes (Admiralty Surface Weapons Establishment, Portsdown, UK) presented complementary papers on track extraction systems and algorithms for track formation. Tuncliffe's paper was mainly concerned with the false alarm problem in conditions where moving target indicator (MTI) processing is not possible, while Holmes described algorithms for track generating and updating. In Holmes' process, all tracks are updated scan by scan using a data smoothing technique based on Kalman filtering but with reduced memory and computer run-time requirements.

A. P. Young (Marconi Radar Systems Ltd, UK) described the application of distributed processing to an air-traffic-control radar network and other applications. The system described uses a data-bus type organization with input/output processors communicating with each other over the bus. The Marconi data handling system is called Locus 16 and uses software written in Coral 66.

Dr. H. Ebert (AEG-Telefunken, W. Germany) presented a paper discussing the application of micro-computers to radar plot extraction. AEG-Telefunken is developing a modular data processor based on a set of commerical microcomputer modules and have intentions to apply it for air traffic control.

In the session on plot tracking and analysis, A. M. Navarro (Physics Laboratory TNO, Netherlands) described a tracking procedure for the FUCAS experimental phased-array system. He has developed a position estimation algorithm optimized to minimize the maximum predicted position error. Simulation tests have been made for his test program, but results of the real system will not be available until 1978.

Two papers from Germany were on the problem of tracking closely spaced air targets moving in formation. G. Binias (Forschungs-Institut für Funk und Mathematik, West Germany) and E. H. Flad (Siemens AG, West Germany) have each developed computer programs which track aircraft formations and split tracks when sufficient radar resolution makes this possible.

C. E. Rykett (Royal Signals and Radar Establishment, UK) is looking at the problem of recognizing targets from their Doppler returns. Specifically he is working on the sub-problem of estimating

the number of targets in a resolution cell. He has developed an orthogonal transformation algorithm that operates on the Doppler spectra and allows good estimation of the number of targets when fed with actual data from moving ground-vehicle targets.

IV. Papers on Detection and Classification

There were six papers in the session on detection and classification of which five were by European authors.

Dr. J. M. Smith (Marconi Radar System, Ltd, UK) gave an overview paper on problems in radar detection theory. A number of problems in this field have been solved in the past 15 years but there are still others awaiting solutions. In general the object of this theoretical work is to determine radar detection probability assuming various detector types, pulse integrators, and threshold settings. Analytical solutions to many cases have been provided and simulation results or numerical solutions have dealt with others. Smith said that one of the major outstanding problems in detection theory is for MTI radar in which distributions of both signal-plus-noise and noise alone are altered.

H. H. Woerrlein (MBB, West Germany) proposed a radar CFAR detector derived from correlation processing in adjacent range bins. Computer simulations of the correlation detector were performed and showed that it had good performance in detecting signals in noise but that its sensitivity was 10 to 12 dB worse than a conventional linear detector.

Some design considerations for a digital adapative filter for real-time processing were presented by R. Klemm (Forschungsinstitut für Funk und Mathematik, West Germany). This work concerned a hardwired processor which minimizes noise power using the steepest descent algorithm. Experiments using up to five loops have been conducted, simulating the algorithm on a computer, and have led to several conclusions among which is the following: Eight-bit arithmetic accuracy for signal quantization is a good compromise between interference suppression rate and costs.

J. H. Blythe and R. Treciokas (Marconi Research Laboratories, UK) have been studying temporal integration as a means of setting thresholds for plot extraction. They have collected clutter data from three Marconi radars and have compared temporal integration and spatial integration in terms of mean-above-clutter loss (MACL) (the absolute difference between threshold and clutter level in each cell). They find that temporal integration is never inferior to spatial integration and in ground clutter environments may yield improvements of around 10dB in MACL.

J. Pahls (SHAPE Technical Centre, Netherlands) described the image processing system being implemented by SHAPE Technical Center for experimental studies. It is hoped to obtain cross-range resolution of an aircraft target on the basis of target motion. A two-dimensional target image processing module is being integrated with a multifunction radar to provide a grid of range and cross-range resolution on the body of the tamget.

V. Papers on Displays

The session on displays at Radar-77 was somewhat disappointing, particularly in view of Sir Hermann's admonition at the outset of the conference that the man-machine interface for radar still needed much work. There were only three papers on displays, and none of them revealed any startling new work nor were there any good reviews of current technology.

J. W. Kime (Marconi Radar Systems, Ltd) presented a talk that purported to be a review of the man-machine interface in surveillance radar systems. However, the main point of the paper was to advertise a Marconi touch-sensitive overlay for providing X-Y inputs to a computer. This panel, the Digilux mask, incorporates infrared emitters along two edges of a cathode-ray-tube (CRT) display panel and detectors on opposite edges. When the IR beams which overlay the display are interrupted by the operator's finger, the indicated position is electronically input to the computer and the position is marked on the display. This clever system is rated as being very efficient in operator time utilization and eliminates the trailing lead wire associated with a light-pen.

An integrating scan, cowerter using digital storage was described by D. R. Clements and C. J. Buck (EMI Electronics Ltd, UK). This item uses 16K RAM's arranged to form a square matrix of 512 by 512 resolution cells. Read or write cycle time is 600 nsec and parallel retrieval with multiplexing achieves TV data readout for display on a 600-line TV system.

A solid-state video mapper employing a 1728-element linear charge coupled device (CCD) was described by R. Inagaki and K. Fukumoto (Nippon Electric Co., Ltd, Japan). The new CCD mapper has much superior resolution than a conventional device employing a photomultiplier. The Nippon Electric mapper sells for about three million yen (<$10K).

VI. Papers on Antennas, Phased Arrays and Multibeam Antennas

Papers on antennas and phased arrays filled three sessions of Radar-77 and constituted a major topic of the conference. The design of sophisticated systems for interference cancellation and null steering is occupying many workers in the radar field, and operational systems are coming into use in many application. There are also a number of research radar systems being developed in Europe, and

these formed the basis of several papers at the conference.

In the session on adaptive antennas, a paper by J. G. Fielding and co-workers (Plessey Avionics and Communications, UK) covered various configurations for adaptive cancellation of interference. He discussed typical performances achieved by single-and multi-loop cancellers and pointed out that as the number of loops grows, the whole system is better considered as an array.

One of the research radars being developed in Europe is the ELRA system of West Germany. W. D. Wirth (Forschungsinstitut für Funk and Mathematik, West FRG Germany) described this system briefly and discussed some of the signal processing schemes that may be applied to it. ELRA is an S-band system with separate 5-m-diam. antenna arrays for transmitting and receiving. There will be 300 elements in the transmitting array and 800 in the receiving array, however, only 200 in each antenna are now operating. The whole system operates with a computer and can do beam forming, antenna pattern shaping and adaptive suppression of directional noise. The findings that will come out of the ELRA project should be of interest to a number of people in the radar community.

L. W. Dicken (Plessey Radar Research Centre, UK) proposes a method of reducing the effect of a main-beam stand-off jammer by steering a monopulse null toward the jammer. In this case a nearby target can be seen above the nulled jammer interference. Plessey are building an experimental X-band system to prove this principle, and results should be available by the end of 1977.

There were seven papers in the session titled "Antennas" (in this case with no additional qualifiers). Unfortunately most were uninspiring and had little content, therefore only a couple will be mentioned.

T. J. Green (Admiralty Surface Weapons Establishment, UK) surveyed the influence of masts on shipborne radar performance. This has always been a troublesome problem, but most apparently good ideas have not succeeded in avoiding losses because of the presence of a mast in the radar's beam. Dielectric coatings, radar absorbent materials, totally dielectric masts, and unusual cross-sectional shapes all fail to reduce blocking effects substantially. The most attractive mast type seems to be an open structure (e.g., framework) with a minimum of obscuring metal.

M. Scorer (Marconi Elliott Avionics Systems, Ltd, UK) discussed the calculation of radome-induced sidelobes and presented some results for airborne radome with application to airborne early warning (AEW) radars. In particular the shapes analyzed look as though they would be those applicable to the AEW-Nimrod aircraft being developed for the RAF. One of the concerns of Scorer's study has been the contribution

to sidelobes caused by radome flash, a subject ignored by most workers.

The session on phased array and multibeam antennas consisted of six papers with very little common thread running through the session. Topics ranged from antennas for synthetic aperture radars to IF beam forming.

J. Thraves (EMI Electronics Ltd, UK) described a yaw-stabilized synthetic-aperture radar aerial for aircraft pod mounting. The entire antenna fits inside a 200-mm-diam. cylindrical volume. Main beam gain was greater than 26 dB.

F. L. Williams (Marconi Research Laboratories, UK) described the design of receiver channels for beam forming at IF. These have been incorporated in an experimental multibeam radar based on hardware originally incorporated in the Within Pulse Scanning Height-finder described by Radford in another paper at Radar-77. The particular problem addressed by Williams was that of aligning gain and phase of the receiving channels to the required accuracy. He seems to feel that an alignment system based on a frequency-multiplexed test-input signal will be the most practical for automatic alignment.

Dr. Jan Snieder and H. J. van Schaik (Physics Laboratory TNO, Netherlands) presented separate papers, related again to the FUCAS experimental phased-array system being developed at TNO. Snieder described a matching method for compensating mutual coupling loss of a linear-phased array (with waveguide apertures as radiating elements). Van Schaik described the use of a dielectric sheet for matching the phased-array radiation to free space. The presence of a plastic sheet in front of the array increased transmitted power by about 2 dB in the 5.4 - 5.9-GHz range.

J. Austin and J. R. Forrest (University College, London, UK) are working on new techniques to reduce the cost of active radar arrays. The effort has centered on eliminating the need for passive phase shifters, and the workers have examined the use of a heterodyne phase-locked loop (HPLL) as an active array element. They have done tests on a single element using a 300-mW pulsed varactor-tuned Gunn oscillator and have built an array of four elements based on the HPLL. Computer simulation studies have been done on a 25-element array to investigate the effects of mutual coupling. The above work is being carried out under a USAF research grant.

VII. Papers on Transmitters and Components

The session on transmitters and components consisted of six papers, all by European authors, some of which are discussed below. The papers on transmitter klystrons seemed concerned mainly with ground-based radars and overall system weights were quite high. It would have been interesting to see some work in weight reduction in this session, but none was evident.

C. H. Hamilton (AEG-Telefunken, West Germany) described a compact PIN diode duplexer which can handle 750-kW peak power over the band 1.25 to 1.35 GHz. The item is of hybrid waveguide/coaxial construction with transmitter power switched through the waveguide and receiver power coupled out via a coaxial circuit. Isolation ranges from 28 to 30 dB over the band.

Dr. J. Snieder (Physics Laboratory TNO, Netherlands), who also gave a paper in the antenna session (cited above), presented some experimental results comparing various non-reciprocal ferrite phase shifters with cylindrical rods at 3, 5.5, 9.3, and 16 GHz. The quality of phase shifters is given by the figure of merit (FOM), the differential phase shift-insertion loss ratio. Graphs were presented showing the FOM as a function of rod diameter for lithium ferrite, Mg Mn ferrite, and mixed garnets. Temperature dependence of differential phase shift was also measured.

J. R. Luscombe (Plessey Radar Limited, UK) described a klystron power amplifier for an MTI/pulse compression radar. The power amplifier is driven at 1-kW peak, 10-W mean at S-Band and has a bandwidth of 200 MHz. One interesting feature of this grid-modulated klystron is that it uses a floating modulator triggered by a fiber-optic link.

M. J. Smith (EMI-Varian Ltd, UK) described the methods used to design the buncher section of a 1-MW S-Band gridded klystron. A summary of this tubes performance is as follows:

Bandwith (instantaneous)	200 MHz
Peak output power	1.0 to 1.2 Mw
Drive power	<1.0 kW
Pulse Length (Nominal)	40µsec
P.R.F. (nominal)	250 Hz
Perveance	2.0 μAV^{-15}
Operating voltage (nominal)	74.6 kV
Operating current (nominal)	40.7 A

P. Marlow and R. J. Sunderland (Marconi Radar Systems Ltd, UK) presented a fairly general paper on designing high-stability transmitters for pulse Doppler radars and measuring their spectral purity. If the dates of the references (ca. 1970) were any indication, this paper could hardly be considered up-to-date. The Marconi Research Division has evidently developed an instrument to measure the noise generated in pulsed-power amplifiers. This equipment is designated VX(E) 13500 and has a linear dynamic range on the order of -125 dB. Two versions have been designed for use in 25-cm and 10-cm bands.

VIII. Conclusion

It is difficult to summarize Radar-77 except to say that it was an excellent conference with a great deal of useful information on current radar R&D. It was one of the best organized conferences this writer has attended, and it is obvious that a great deal of

effort went into selecting the papers, arranging the sessions, and chairing them with scrupulous attention to timing. There were very few "dud" papers, and I am sure the proceedings will be a valuable reference source for radar engineers throughout the world. I have included in appendix 1 the complete list of papers presented at Radar-77 arranged alphabetically by author.

The conference proceedings are available from the IEE (UK) or from the IEEE (USA) and carry two references: The IEE reference is Conference Publication No. 155; IEEE catalog number is 77CH1271-6 AES. If ordered from the UK the address is:

The Institution of Electrical Engineers
Savoy Place
London WC2R OBL

The price for the complete conference proceedings is £24.10 ($44.20) including overseas posting by surface mail.

APPENDIX I

List of Papers at Radar 77

25-28 Oct 77

D. F. Albanese
Pseudo-random code waveform design trade-offs for CW radar applications

S. J. Alexander, A. Barbour, J. Ward, M. Alldritt, R. Jones, J. M. Vaughan and D. J. Watson
A 10 μm band laser radar anemometer

J. Austin and J. R. Forrest
Low cost steerable active array element design

P. D. A. Baird
RF simulation for co-ordination of ECCM

M. R. Barnett, J. R. Luscombe and C. R. White
An inverter powered, one megawatt klystron power amplifier for a radar transmitter

D. K. Barton
Radar multipath theory and experimental data

P. Barton, A. Wong, K. Kelly and P. Gwynn
Array signal processing for tracking targets at low elevation angles

G. Binias
Computer controlled tracking in dense target environment using a phased array antenna

J. H. Blythe and R. Treciokas
The application of temporal integration to plot extraction

J. K. Brittain, E. J. Schroeder and A. E. Zebrowski
Effectiveness of range extended background normalization in ground and weather clutter

M. R. Buchner
A multistatic track filter with optimal measurement selection

J. S. Burgess
Recent advances in radar technology

R. H. J. Cary
Some novel techniques for avoiding antenna obscurations and EMC effects

P. G. Casner and R. J. Prengaman
Integration and automation of multiple co-located radars

F. R. Castella and J. T. Miller Jr.
Moving target detector data utilization study

P. J. B. Clarricoats
Portable radar for the detection of buried objects

D. R. Clements and C. J. Buck
An integrating scan converter using digital storage

J. G. Cochran
Current developments in the design of air defence ground radar systems

L. A. Cram, M. R. Gilday and K. O. Rossiter
Basic radar evaluation by computer simulation

L. A. Cram and J. R. Staveley
Recent developments in scale modelling of radar reflections by radar and sonar methods

E. Dalle Mese and D. Giuli
Echo discrimination in a dense target environment

D. J. Daniels
The use of radar in geophysical prospecting

D. E. N. Davies, C. D. McEwen and C. R. Ward
A high resolution radar incorporating a mechanical scanning transmitter and a static multi-beam receiver

L. W. Dicken
The use of null steering in suppressing main beam interference

G. M. Dillard
Radar signal processing using fiber and integrated optics

O. L. Dixon
Significance of edge-point-estimation tracking in precision approach radar systems

F. B. Dyer, N. C. Currie and M. S. Applegate
Radar backscatter from land, sea, rain, and snow at millimeter wavelengths

H. Ebert
Radar data processing using microcomputers

B. L. Elphick, M. J. Chappell and R. Batty
The measured and calculated RCS of a resistive target model

D. A. Ethington
The AN/TPQ-36 and AN/TPQ-37 FIREFINDER radars

R. J. Evans
Design of robust sidelobe suppression filters

E. F. Ewing
The applicability of bistatic radar to short range surveillance

H. Fancy
Multi-filter MTI system

F. A. Fay, J. Clarke and R. S. Peters
Weibull distribution applied to sea clutter

J. J. Fee
Considerations in the selection of a radar beacon for maritime use

W. Fenster
The application, design, and performance of over-the-horizon radars

J. G. Fielding, D. H. Brandwood, G. Raymond, T. A. Bristow and C. J. Tarran
Adaptive interference cancellation in radar systems

E. H. Flad
Tracking of formation flying aircraft

M. A. Flemming, F. H. Mullins and A. W. D. Watson
Harmonic radar detection systems

J. R. Forrest and J. P. Meeson
Solid state microwave noise radar

C. H. Gager and R. B. Van Deusen
Generation of flexible pulse compression waveforms with computer control

T. J. Green
The influence of masts on ship-borne radar performance

W. A. Grinsted
The mapping of rainfall by radar

C. H. Hamilton
A compact PIN diode duplexer in L-band waveguide

D. S. Harris
The detection of electricity pylons and cables by radar

D. Hayes
A technique for automatically identifying the axis of symmetry of co-phasal array antenna patterns

M. Hidayet and P. A. McInnes
On the specification of an antenna pattern for a synthetic aperture radar

F. P. Hiner III
The L2000, a remote radar signal and data processor

J. E. Holmes
The development of algorithms for the formation and updating of tracks

R. C. Houts
Velocity response characteristics of MTI radars using pulse or block stagger

D. D. Howard
Investigation and application of radar techniques for low-altitude target tracking

J. K. Hsiao and J. P. Shelton
A phased array maintenance monitoring system

A. T. Humphrey
Structural and thermal performance analysis for radar antenna design

R. Inagaki and K. Fukumoto
Solid-state video mapper

T. Irabu, E. Kiuchi, T. Hagisawa and Y. Tomita
Range-azimuth correlation processor in the frequency domain for a primary radar

E. Jakeman and P. N. Pusey
Statistics of non-Rayleigh microwave sea echo

R. R. Kelly and S. Charton
A programmable digital signal processor evaluated for radar applications

F. W. Kime
Evolution of the man-machine interface in surveillance radar systems

I. E. King, A. A. Albanese and H. A. Burris
The AN/TPS-59 and GE592—a family of solid-state radars

R. Klemm
Design considerations for a digital adaptive least squares filter for real-time processing

J. J. Kroszczyński
Polish radar developments

B. L. Lewis and I. D. Olin
Some recent observations of sea spikes

P. Marlow and R. F. Sunderland
Design of high-stability transmitters for pulse doppler radars and measurement of their spectral purity

J. T. Miller Jr. and J. P. Berry
Multisensor utilization investigation

K. Milne
Principles and concepts of multistatic surveillance radars

Lj. Milosevic and M. Lenoir
Stochastic response secondary surveillance radar (SRSSR)

E. Morgan
A technical review of the radar systems implemented by Eurocontrol

A. R. Morley and A. S. Wilsdon
Multiradar tracking in a multisite environment

C. E. Muehe, P. G. McHugh, W. H. Drury and B. G. Laird
The parallel microprogrammed processor (PMP)

A. M. Navarro
Procedure for tracking manoeuvring targets with a multi-purpose phased-array radar system

G. Neininger
An FM/CW radar with high resolution in range and doppler; application for anti-collision radar for vehicles

R. B. Nicholls
Advances in the design of Foster scanners

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Quad-pulse radar—a frequency agile radar with doppler capability

C. J. Oliver
A comparison of radar principles at microwave and optical frequencies

J. Pahls
Radar moving target resolution and imaging

K. E. Potter
Experimental design study of an airborne interferometer for terrain avoidance

B. A. Prew
The influence of oscillator noise on the performance of coherent solid-state ground surveillance radars

C. E. Pykett
Automatic estimation of the number of radar targets in a resolution cell

M. F. Radford
System applications of beam forming networks

E. R. Richards
Use of radar beacons in the civil marine service

G. C. Rider
A polarisation approach to the clutter problem

J. Riegl and P. Aigner
A laser secondary radar for automatic collision avoidance

M. B. Ringel
Computer-calculated ground clutter for a maneuvering pulse doppler radar

J. B. G. Roberts, R. Eames, D. V. McCaughan and M. B. N. Butler
A new approach to pulse doppler processing

A. W. Rudge and N. A. Adatia
Primary feeds for boresight-jitter compensation of offset-reflector radar antennas

D. C. Schleher and D. Schulkind
Optimization of nonrecursive digital MTI

B. P. Scoffield and L. N. Simcox
Design and evaluation of a receiver to eliminate SSR air to ground reflections at Clee Hill radar by amplitude discrimination

M. Scorer
The calculation of radome induced sidelobes

M. Scorer and C. D. Watkins
An advanced man portable surveillance radar

E. D. R. Shearman, D. J. Bagwell and W. A. Sandham
Progress in remote sensing of sea-state and oceanic winds by HF radar

L. N. Simcox
A method of automatic alignment of SSR radars with overlapping cover

H. Sittrop
On the sea-clutter dependency on windspeed

J. M. Smith
Problems solved and unsolved in radar detection theory

M. J. Smith, D. Perring and G. Phillips
A one megawatt S-band gridded klystron for a wide band pulse compression radar

N. H. A. Smith
Developments in radar data processing at the London Air Traffic Control Centre

J. Snieder
A simple and fast matching method for mutual coupling of a linear phased array antenna with waveguide apertures as radiating elements

J. Snieder
A survey of properties of latched non-reciprocal ferrite phase shifters with cylindrical rods at 3, 5.5, 9.3 and 16 GHz

F. Søndergaard
A dual mode digital processor for medium resolution synthetic aperture radars

D. C. Stoner
Adaptive MTI and signal processing techniques for long range chaff and weather

J. W. Sutherland
World market trends in radar for defence and air traffic control

R. G. Taylor, T. S. Durrani and C. Goutis
Block processing in pulse doppler radar

J. Thraves
A yaw stabilised SAR aerial

G. Tickle
Radar system simulation and performance prediction

G. V. Trunk
Automatic detector for suppression of sidelobe jamming

R. J. Tunnicliffe
A simple automatic radar track extraction system

R. M. Turner
Null placement and antenna pattern synthesis by control of the element steering phases of a phased-array radar

V. Utsi
Real time radar signal simulator

P. van der Kraan
Evaluation of the Eurocontrol radar chains

G. A. van der Spek
FUCAS, an experimental phased-array radar system

P. Van Etten
The present technology of impulse radars

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Theoretical and experimental results of an iris-loaded, planar, phased-array antenna with an external dielectric sheet

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A contribution to radar target classification

H. J. Wells
The performance of balanced processing for ground clutter suppression in microwave radars

I. White
Signal processing simulation of a non-linear FM frequency scanned pulse compression radar

P. D. L. Williams, H. D. Cramp and W. E. Bellion
The passive enhancement of navigation buoys at sea. Results and analysis of a 9-month comparative trial

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Multiple channel receivers for IF beam forming

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Radar signal processing with an active receiving array

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CFAR-detector derived from correlation processing in adjacent range bins

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SAW sidelobe reduction filter for Barker codes

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Enhancements of radar data-handling networks